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Calibration of A354 bolts (preliminary report), March 1963

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CALIBRATION OF A354 BOLTS

(PRELIMINARY REPORT)

by

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SYNOPSIS

Presented in this report are the results of calibration tests of individual ASTM A354BC and A354BD quenched and tempered alloy steel bolts. The bolts reported herein were 7/8-inch and 1-inch nominal diameter. Results of 54 direct tension and 110 torqued tension tests are presented. The major variables studied were diameter, grip, thread in grip, and thread lubrication. Both the heavy head and the regular head bolt were studied.

This is a preliminary report and will eventually be incorporated into a report which will also include special studies such as repeated torqued tension and combined torqued-then direct tension tests. Appendix A shows the complete testing program.

1. INTRODUCTION

The purpose of this investigation is to determine the behavior of the A354 bolt in torqued tension and to compare this to its direct tension behavior. A knowledge of the properties of the bolt are required to determine its feasibility as a structural fastener and to evaluate its effectiveness in resisting slip between connected parts. The resistance to slip in a bolted joint is directly dependent upon clamping force present in the bolts and the bearing conditions.

This report presents results of tests of 7/8 and 1-inch diameter A354BC and BD bolts, with lengths under head from 5.25 to 9.50 inches, and with 1/8 to 1-inch of thread in the grip. Two types of bolts were tested within each grade. One type conformed to the requirements for regular semi-finished bolts as specified in ASA B18.2(1) and called for in the ASTM A354 specification(2). The second type was similar in geometry to the ASTM A325(3) heavy hexagon structural bolt. This bolt has a larger head and a shorter thread length than the first type. All bolts of both types and grades had cut threads. ASTM A194, grade 2H nuts were used with all bolts. The bolt geometry is summarized in tables 1 to 4.

All bolts used for this study were of special manufacture since the A354 bolt is not yet in general use. The heavy head bolts were made by reheat-treating 4140 Canadian bolts. As a result, variations in physical properties exist between the various lots of bolts.

Each bolt was checked for fit with NC2A go and no-go ring gages and each nut was checked with NC2B go and no-go plug gages. Only those bolts and nuts which were satisfactory were tested.

2. TEST PREPARATION AND PROCEDURE

Before testing, all bolts were classified by stamping the lot designation and the bolt number on the end of each bolt. The lot designation identified each bolt as to grade and geometry. Holes were also drilled in the center of each end of the bolt to accomodate a C-frame extensometer.

The direct tension tests were made in a 300 kip hydraulic testing machine at a speed of approximately 0.01 inches per minute. Before testing, an initial reading was made with the C-frame extensometer and the length under head was measured with a steel scale. During the inelastic range of loading and before reaching the ultimate load, the machine was stopped one or more times to determine the static load level.

The torqued tension tests were conducted in a commercial calibrator[(4)]. The bolt was first placed in the calibrator and tightened to a tension of 8 kips to approximate the snug position. The nut was then rotated in 45° increments (1/8-turn) with a pneumatic impact wrench until failure. Load and elongation measurements were taken at each increment. Additional details of these tests are reported in Reference 5.

The A354BC bolts were received without the usual light coating of shipping oil. Before testing they were coated with a water diluted oil similar to that in general use for shipping purposes.

Four lots of grade BC bolts and eight lots of grade BD bolts were tested. Bolts having heavy heads were tested with two initial lengths of thread between the bottom face of the nut and the thread run out. These lengths were 1/8 and 9/16 inches respectively, for the 7/8 inch bolts, and 1/8 and 11/16 for the 1 inch bolts. These values corresponded approximately to one and six full threads. The regular head bolts, which had the ASA B18.2 standard thread lengths were tested with 3/4" of thread between the bottom face of the nut and the thread run out for the 7/8 inch bolts and 1 inch for the one inch bolts.

To maintain these thread lengths, the grip length was varied between 3.38" and 4.25" for the shorter bolts and between 7.38" and 8.06" for the longer bolts. Three bolts were tested from each lot for specified lengths of thread under the nut for the direct tension tests.

The torqued tension tests were conducted with two conditions of thread lubrication. The first condition corresponded to the "as received" condition, that is the threads had a light residual coating of shipping oil. For the second condition the threads were lubricated liberally with a heavy commercial lubricant ("Lubriplate"). Six bolts were tested for each thread length in grip, three for each type of lubrication.

3. TEST RESULTS

The test results are summarized in Tables 1 through 4. Tables 1 and 2 indicate the significant loads and corresponding elongations for the direct and the torqued tension tests of the BC grade bolts, while Tables 3 and 4 give this information for the BD grade bolts. Standard deviations are shown only for the ultimate loads attained.

Eighteen BC bolts and 36 BD bolts were tested in direct tension, while 36 BC bolts and 74 BD bolts were tested in torqued tension.

The 7/8 inch nuts and all BC bolts were received completely lacking of shipping oil. It was attempted to test three of these bolts in torqued tension and the attempts met with varying degrees of failure. The first bolt reached a load of 38.5 kips at one half turn after which the impacting could cause no further nut rotation in either direction and the nut was burned off. The second bolt reached one turn and a load of 47.3 kips with the same results. The third bolt was tightened by hand to 8 kips and it had already bound so badly that the nut could not be removed by the impact wrench and it had to be burned off. Because of this severe behavior, lubrication of threads was included as a major variable for the torqued tension tests.

Load-elongation relationships in direct tension and in torqued tension are compared in Figs. 2, 3 and 5 for three different lots of BD grade bolts. The results of tests of 7/8-inch bolts are shown in Figs. 2 and 3. Fig. 5 shows the results of tests of 1-inch bolts. Two torqued tension relationships are shown in each figure; one with the threads in the "as received" condition and the other with the threads lubricated. The AD lot shown in Fig. 2 had the greatest increases with the addition of lubricant. An examination of Tables 3 and 4 indicates that bolts with the shorter thread length (BD grade) had the greatest increase in their ultimate load when lubricant was applied, while the increase in load was negligible for larger lengths of the grip. This trend can be seen by comparison of Figures 2 and 3.

The load-elongation relationships of the BC grade bolts are illustrated in Figures 1 and 4 for the 7/8-inch and 1-inch bolts respectively. The addition of lubricant had little if any, effect on the ultimate load or turns to failure.

Figures 1 through 5 also show the locations of 1/2 and 3/4 turn of the nut. The method used to induce internal tension had no effect on the elastic portion of the load-elongation relationship, but a reduction in strength is apparent for the torqued tension tests in the inelastic range. The ultimate strength of a bolt in torqued tension was from 79% to 94.5% of the direct tensile strength of the same bolt.

The mode of failure for all tests was combined tensile and diagonal shearing fracture. The shearing fracture became more predominant for the torqued tension tests. Only two failed by threads stripping and for the other bolts most of the nuts turned freely on the threads after failure.

The effects of thread length in the grip are shown in Figures 6 and 7 for torqued tension tests of two sizes of BD Grade bolts. These curves are typical of the behavior for other lots. Decreasing the length of thread between the thread run out and the face of the nut resulted in an increase in the bolts strength. The number of turns to failure was not significantly affected by the length of thread in the grip for the 7/8-inch bolts. For the 1-inch bolts, the number of turns to failure was reduced slightly when the length of thread in the grip was decreased. Figure 8 summarizes the effect of thread length on the rotation capacity.

The slope of the elastic curve is affected by both grip and thread in grip as would be expected. The effect of thread in grip may be seen in Figures 6 and 7, while the effect of grip may be seen by comparison of

Figures 2 and 6. Longer grip or thread in grip results in a reduction in the slope of the elastic curve. This reduction in slope in turn lowers the load induced by a given nut rotation and subsequent elongation within the elastic range. Because of high proof loads for these bolts, the load induced by one half turn-of-nut remains in or near the elastic range and is therefore subject to great variation as small changes in elongation produce significant changes in tension.

All 7/8-inch diameter A354BC bolts sustained approximately 1-3/4 turns before failure, while the 1-inch BC grade bolt sustained only about 1-1/2 turns. There was no apparent effect of lubrication upon the bolt's performance. However, it should be noted that the threads were treated with a water soluble oil shortly before testing. This may have provided greater lubrication than may normally exist in the "as received" condition.

The 7/8-inch A354BD bolts sustained 1-1/4 to 1-3/4 turns before failure when tested in the "as received" condition. The 1-inch BD Grade bolts sustained 1 to 1-7/8 turns. When the threads of BD Grade bolts were lubricated the turns to failure were increased by about 3/16 turn.

Considerable variation was noted in the number of turns to failure. For the A354BD bolts (7/8 and 1-inch) the range was from 1 to 2 turns. For the A354BC bolts (7/8 and 1-inch) the range was 1-1/4 to 2 turns. The application of lubrication to the threads decreased the scatter in the turns to failure.

4. CONCLUSIONS

A354BC Grade Bolts

1. The ultimate strength of the bolt when tested in direct tension was 11 to 19 percent greater than that obtained when turning the nut against the resistance of the gripped material. The elongations at rupture were 14 to 139 percent greater. These effects can be seen in Figures 1 and 4. Similar effects were noted for previous tests of A325 and A354 bolts[5] [6].

2. A lesser amount of exposed thread under the nut resulted in an increase in the ultimate strength. This was true for both direct and torqued tension tests.

Similar results were experienced at the University of Illinois.[6]

3. The length of thread between the thread run out and the face of the nut had only a slight effect on the number of turns to failure, as can be seen in Fig. 8. With 1/8-inch of thread under the nut, the 7/8-inch bolts experienced about 1-1/2 turns to failure and the same bolts with 9/16-inch of thread under the nut, experienced about 1-3/4 turns to failure. For the 1-inch bolts about 1-1/4 and 1-3/8 turns were experienced with 1/8 and 11/16-inches of thread in the grip, respectively. Approximately the same results were achieved with earlier tests of the A325 bolt.[5]

4. The preload induced by one half turn-of-nut exceeded the proof load in all cases. However, the strengths of these bolts in direct tension were 8 to 26 percent greater than the minimum specified tensile strength and the maximum length of grip was only 4.25 inches.

5. Thread lubrication had no appreciable effect on the performance of the bolt.

6. There was no appreciable difference in the behavior of the regular and heavy head bolts.

7. The 1-inch diameter bolts had less capacity for elongation during tightening as they experienced approximately 1/4 of a turn less at rupture

<u>A354BD Grade Bolts</u>

1. The ultimate strength of the BD grade bolts when tested in direct tension was 6 to 27 percent greater than that obtained during the torqued tension tests. This increase can be seen in Figures 2, 3 and 5 and was noted also for previous tests of A325 and A354 bolts.[5][6]

2. A lesser amount of exposed thread under the nut resulted in an appreciable increase in the ultimate strength, as can be seen in Figures 6 and 7. This was true for both direct tension and torqued tension tests, and agrees with other investigations.[5][6]

3. The length of thread between the thread run out and the face of the nut had no appreciable effect on the turns to failure of 7/8-inch bolts. The 1-inch bolts with short threads had less capacity for elongation during tightening. As the length of thread was decreased from 11/16 to 1/8-inches the turns to failure decreased by 1/4 to 3/8 of a turn.

4. Thread lubrication was the most beneficial for the shorter length of exposed thread under the nut and the decrease in the torsional components resulted in a higher ultimate load. The application of the lubricant increased the turns to failure by 1/4 turn, so that the turns to failure were about the same as for the A325 bolt.(5) Figures 2 and 5 show these relationships for 1/8-inch of thread in the grip.

5. For grips up to 4.25 inches, the load induced by one half turn-of-nut usually exceeded the proof load with or without thread lubrication. For the longer grips between 7.6 and 8 inches, the proof load could not be reached by one half turn-of-nut with or without thread lubrication. Figures 2 and 6 are typical in this respect for the short and the long grips.

6. There was no appreciable difference in the behavior of the regular and heavy head bolts.

TABLE 1

A354 BC BOLTS - 7/8 INCH DIAMETER

Bolt Lot		AC	AC	CC
Head Type		Hvy.	Hvy.	Reg.
Length Under Head	in.	5.25	5.25	5.50
Grip Length	in.	3.625	4.062	4.25
Thread Length	in.	1.75	1.75	2.00
Thread Length In Grip	in.	0.125	0.562	0.75
Specified Proof Load (ASTM)	kips	48.5	48.5	48.5
Spcfd. Min. Ult. Load (ASTM)	kips	57.75	57.75	57.75
DIRECT TENSION CALIBRATION*				
No. Specimens Tested		3	3	3
Ultimate Load	kips	72.6	65.0	62.3
Std. Dev.	kips	1.88	1.57	0.20
% Min. Ultimate Load	%	126	113	108
Rupture Load	kips	64.3	52.0	48.7
Elong. at Proof Load	in.	.0114	.0136	.0139
Elong. at Ultimate Load	in.	.0854	.0758	.0900
Elong. after Rupture	in.	.173	.190	.300
TORQUED TENSION CALIBRATION* Threads as received (simulate				
No. Specimens Tested		3	3	3
Load of 1/2 Turn	kips	49.1	52.8	51.1
Ultimate Load	kips	61.3	56.5	55.7
Std. Dev.	kips	1.36	0.87	0.30
% Min. Ultimate Load	%	106	98	96.5
% of Direct Tension Ultimate		84.5	87.0	89.5
Rupture Load	kips	47.0	36.7	40.3
Elong. at Proof Load	in.	.0122	.0165	.0170
Elong. at 1/2 Turn	in.	.0128	.0260	.0227
Elong. at Ult. Load	in.	.0512	.0614	.0669
Elong. after Rupture	in.	.113	.167	.160
No. Turns to Rupture		1-1/2	1-3/4	1-7/8
TORQUED TENSION CALIBRATION* Threads Lubricated				
No. Specimens Tested		3	3	3
Load at 1/2 Turn	kips	51.5	52.0	50.8
Ultimate Load	kips	62.5	56.8	55.2
Std. Dev.	kips	1.13	0.50	0.53
% Min. Ultimate Load	%	108	98.5	95.5
% of Direct Tension Ultimate		86	87.5	89
Rupture Load	kips	44.3	40.3	43.0
Elong. at Proof Load	in.	.0121	.0170	.0180
Elong. at 1/2 Turn	in.	.0130	.0225	.0231
Elong. at Ultimate Load	in.	.0555	.0583	.0628
Elong. after Rupture	in.	.117	.157	.160
No. Turns to Rupture		1-5/8	1-3/4	1-7/8

* Mean values reported

TABLE 2

A354 BC BOLTS - 1 INCH DIAMETER

Bolt Lot		BC	BC	BD
Head Type		Hvy.	Hvy.	Reg.
Length Under Head	in.	5.25	5.25	5.50
Grip Length	in.	3.375	3.938	4.25
Thread Length	in.	2.00	2.00	2.25
Thread Length in Grip	in.	0.125	0.688	1.00
Specified Proof Load (ASTM)	kips	63.65	63.65	63.65
Spcfd. Min. Ult. Load (ASTM)	kips	75.75	75.75	75.75
DIRECT TENSION CALIBRATION*				
No. Specimens Tested		3	3	3
Ultimate Load	kips	91.0	82.9	83.1
Std. Dev.	kips	2.26	1.60	1.22
% Min. Ultimate Load	%	120	109	110
Rupture Load	kips	76.3	61.7	64.0
Elongation at Proof Load	in.	.0115	.0139	.0141
Elongation at Ultimate Load	in.	.0783	.0919	.1079
Elongation after Rupture	in.	.140	.263	.293
TORQUED TENSION CALIBRATION* Threads as received (simulated)				
No. Specimens Tested		3	3	3
Load at 1/2 Turn	kips	75.3	70.2	70.8
Ultimate Load	kips	78.5	72.7	74.5
Std. Dev.	kips	3.50	4.49	1.50
% Min. Ultimate Load	%	104	96	98.5
% of Direct Tension Ult.	%	86.5	88	90
Rupture Load	kips	43.3	51.3	49.7
Elongation at Proof Load	in.	.0110	.0150	.0150
Elongation at 1/2 Turn	in.	.0202	.0291	.0299
Elongation at Ultimate Load	in.	.0389	.0473	.0562
Elongation after Rupture	in.	.110	.110	.170
No. Turns to Rupture		1-1/4	1-1/4	1-3/4
TORQUED TENSION CALIBRATION* Threads Lubricated				
No. Specimens Tested		3	3	3
Load at 1/2 Turn	kips	74.2	67.2	70.2
Ultimate Load	kips	76.5	71.5	73.7
Std. Dev.	kips	1.80	3.00	3.34
% Min. Ultimate Load	%	101	94	97.5
% of Direct Tension Ult.	%	84	86.5	89
Rupture Load	kips	52.0	51.3	54.7
Elongation at Proof Load	in.	.0125	.0160	.0155
Elongation at 1/2 Turn	in.	.0208	.0220	.0243
Elongation at Ultimate Load	in.	.0371	.0518	.0608
Elongation after Rupture	in.	.103	.133	.153
No. Turns to Rupture		1-1/4	1-1/2	1-3/4

* Mean values reported

TABLE 3

A354 BD BOLTS - 7/8 INCH DIAMETER

Bolt Lot		AD	AD	ED	CD	CD	GD
Head Type		Hvy.	Hvy.	Reg.	Hvy.	Hvy.	Reg.
Length Under Head	in.	5.25	5.25	5.50	9.25	9.25	9.50
Grip Length	in.	3.625	4.062	4.25	7.625	8.062	8.00
Thread Length	in.	1.75	1.75	2.00	1.75	1.75	2.25
Thread Length in Grip	in.	0.125	0.562	0.75	0.125	0.562	0.75
Specified Proof Load (ASTM)	kips	55.45	55.45	55.45	55.45	55.45	55.45
Spcfd. Min. Ult. Load (ASTM)	kips	69.3	69.3	69.3	69.3	69.3	69.3
DIRECT TENSION CALIBRATION*							
No. Specimens Tested		3	3	3	3	3	3
Ultimate Load	kips	83.1	76.5	77.8	82.6	74.5	75.5
Std. Dev.	kips	2.63	1.51	0.67	1.25	0.44	0.82
% Min. Ultimate Load	%	120	110	112	119	108	109
Rupture Load	kips	78.3	68.7	71.7	79.2	69.8	71.0
Elong. at Proof Load	in.	.0134	.0156	.0159	.0256	.0281	.0275
Elong. at Ult. Load	in.	.0459	.0605	.0619	.0702	.0807	.0839
Elong. after Rupture	in.	.083	.113	.120	.120	.120	.137
TORQUED TENSION CALIBRATION* Threads as Received							
No. Specimens Tested		3	3	4	3	4	3
Load at 1/2 Turn	kips	48.9	60.9	59.2	45.7	46.9	32.7
Ultimate Load	kips	70.5	66.9	67.6	71.9	62.6	69.3
Std. Dev.	kips	1.82	2.11	1.95	1.85	2.06	0.87
% Min. Ultimate Load	%	102	96.5	97.5	104	90.5	100
% of Direct Tension Ult.	%	85	87.5	87	87	84	92
Rupture Load	kips	58.0	53.0	52.8	66.7	56.2	58.0
Elong. at Proof Load	in.	.0147	.0165	.0168	.0270	.0285	.0265
Elong. at 1/2 Turn	in.	.0127	.0209	.0183	.0219	.0240	.0155
Elong. at Ult. Load	in.	.0376	.0510	.0484	.0652	.0610	.0725
Elong. after Rupture	in.	.080	.120	.145	.110	.105	.127
No. Turns to Rupture		1-1/4	1-3/8	1-3/8	1-3/8	1-1/4	1-3/4
TORQUED TENSION CALIBRATION* Threads Lubricated							
No. Specimens Tested		3	3	3	3	3	3
Load at 1/2 Turn	kips	60.3	58.0	61.9	47.8	46.7	36.1
Ultimate Load	kips	78.6	65.8	68.5	76.1	66.6	68.1
Std. Dev.	kips	1.46	6.25	0.45	0.93	0.82	0.70
% Min. Ultimate	%	113	95	99	110	96	98.5
% of Direct Tension Ult.	%	94.5	86	88	92	89.5	90.5
Rupture Load	kips	59.3	50.3	58.0	58.0	56.3	60.3
Elong. at Proof Load	in.	.0135	.0195	.0155	.0270	.0290	.0270
Elong. at 1/2 Turn	in.	.0152	.0199	.0192	.0228	.0239	.0163
Elong. at Ult. Load	in.	.0496	.0537	.0489	.0627	.0630	.0651
Elong. after Rupture	in.	.127	.150	.137	.143	.133	.107
No. Turns to Rupture		1-1/2	1-5/8	1-1/2	1-3/4	1-1/2	1-5/8

* Mean values reported

TABLE 4

A354 BD BOLTS - 1 INCH DIAMETER

Bolt Lot		BD	BD	FD	DD	DD	HD
Head Type		Hvy.	Hvy.	Reg.	Hvy.	Hvy.	Reg.
Length Under Head	in.	5.25	5.25	5.50	9.25	9.25	9.50
Grip Length	in.	3.375	3.938	4.25	7.938	7.375	7.75
Thread Length	in.	2.00	2.00	2.25	2.00	2.00	2.75
Thread Length in Grip	in.	0.125	0.688	1.00	0.125	0.688	1.00
Specified Proof Load (ASTM)	kips	72.70	72.70	72.70	72.70	72.70	72.70
Spcfd. Min. Ult. Load (ASTM)	kips	90.90	90.90	90.90	90.90	90.90	90.90
DIRECT TENSION CALIBRATION*							
No. Specimens Tested		3	3	3	3	3	3
Ultimate Load	kips	102.1	100.0	99.3	105.4	96.7	100.5
Std. Dev.	kips	1.83	0.20	2.18	0.71	0.53	1.25
% Min. Ultimate Load	%	112	110	109	116	106	110
Rupture Load	kips	92.0	92.3	81.3	93.3	85.3	91.7
Elongation at Proof Load	in.	.0138	.0161	.0169	.0258	.0277	.0280
Elongation at Ultimate Load	in.	.0611	.0747	.0899	.0841	.0909	.0938
Elongation after Rupture	in.	.127	.143	.207	.147	.173	.137
TORQUED TENSION CALIBRATION* Threads as received							
No. Specimens Tested		3	3	3	3	3	3
Load at 1/2 Turn	kips	84.5	72.5	77.8	64.0	67.0	66.7
Ultimate Load	kips	90.7	83.0	88.2	90.3	84.0	91.2
Std. Dev.	kips	0.58	7.86	2.36	1.15	2.65	1.44
% Min. Ultimate Load	%	100	91.5	97	99.5	92.5	100.5
% of Direct Tension Ult.	%	89	83	89	85.5	87	91
Rupture Load	kips	71.7	58.0	68.8	70.7	59.7	75.3
Elongation at Proof Load	in.	.0140	.0165	.0175	.0260	.0280	.0270
Elongation at 1/2 Turn	in.	.0181	.0173	.0222	.0223	.0262	.0250
Elongation at Ultimate Load	in.	.0280	.0441	.0541	.0498	.0537	.0616
Elongation after Rupture	in.	.103	.120	.143	.107	.147	.173
No. Turns to Rupture		1	1-3/8	1-3/8	1-1/4	1-5/8	1-3/4
TORQUED TENSION CALIBRATION* Threads Lubricated							
No. Specimens Tested		3	3	3	3	3	3
Load at 1/2 Turn	kips	83.5	68.0	61.3	58.3	69.7	61.7
Ultimate Load	kips	91.3	78.8	85.5	99.0	85.0	90.3
Std. Dev.	kips	7.37	5.80	8.26	2.78	3.28	2.08
% Min. Ultimate Load	%	100.5	86.5	94	109	93.5	99.5
% of Direct Tension Ult.	%	89.5	79	86	94	88	90
Rupture Load	kips	73.7	60.3	66.3	77.0	58.7	68.0
Elongation at Proof Load	in.	.0140	.0180	.0220	.0255	.0280	.0280
Elongation at 1/2 Turn	in.	.0178	.0170	.0164	.0201	.0269	.0236
Elongation at Ultimate Load	in.	.0367	.0401	.0611	.0603	.0684	.0869
Elongation After Rupture	in.	.100	.117	.180	.115	.153	.170
No. Turns to Rupture		1-1/8	1-3/8	1-7/8	1-5/8	1-3/4	1-7/8

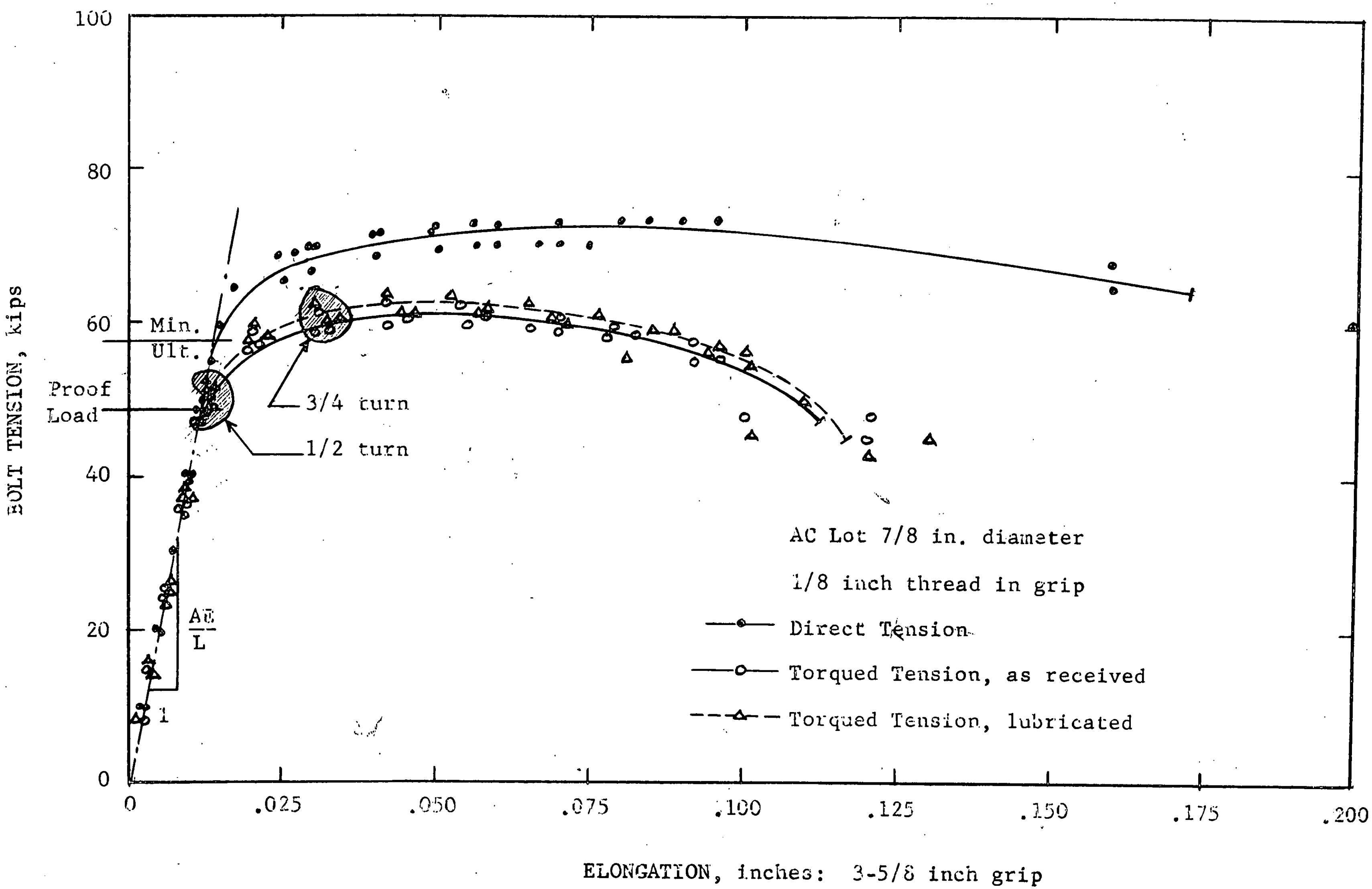

FIGURE 1: LOAD ELONGATION RELATIONSHIP, A354BC BOLT

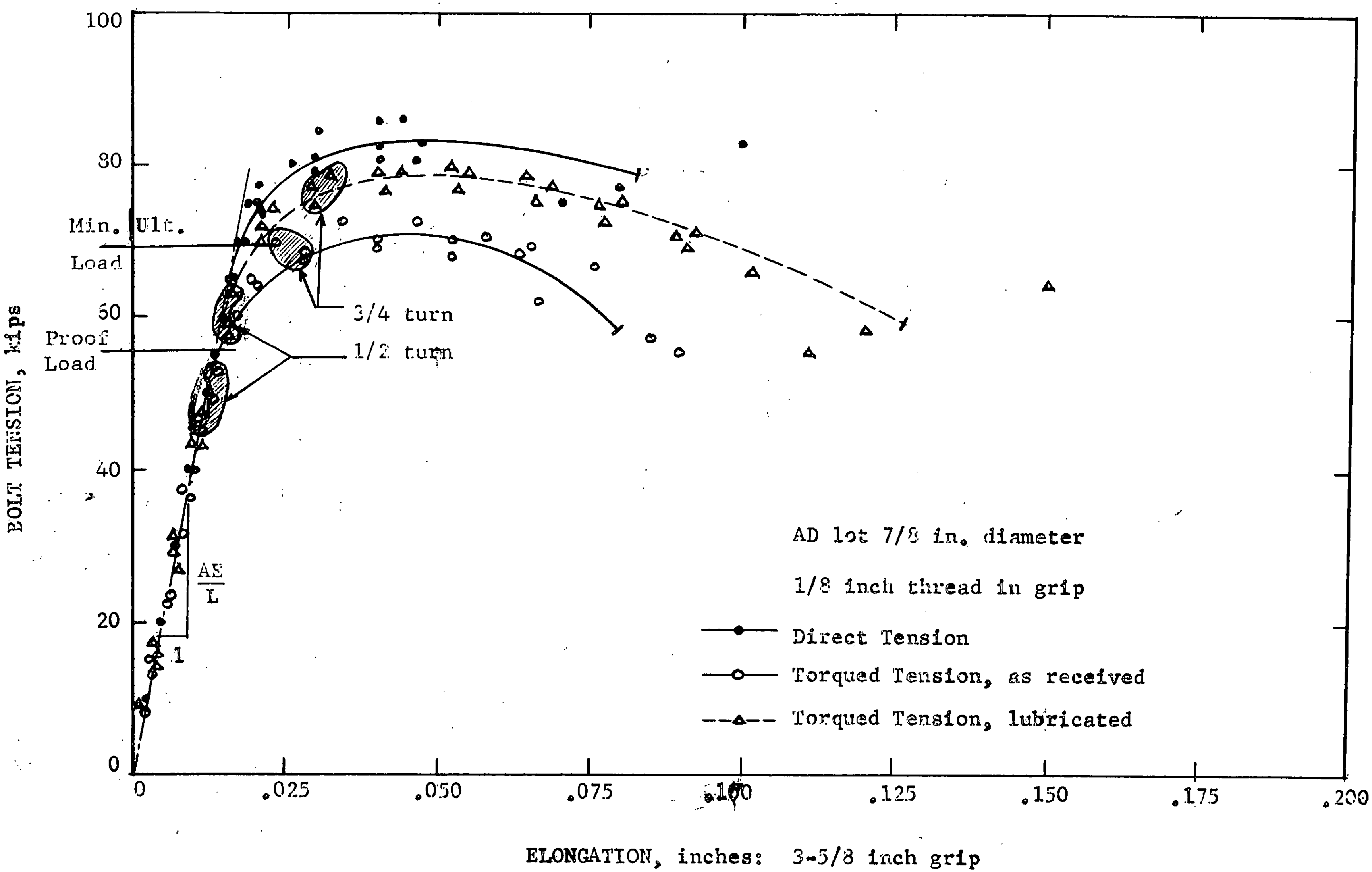

FIGURE 2: LOAD ELONGATION RELATIONSHIP, A354BD BOLT

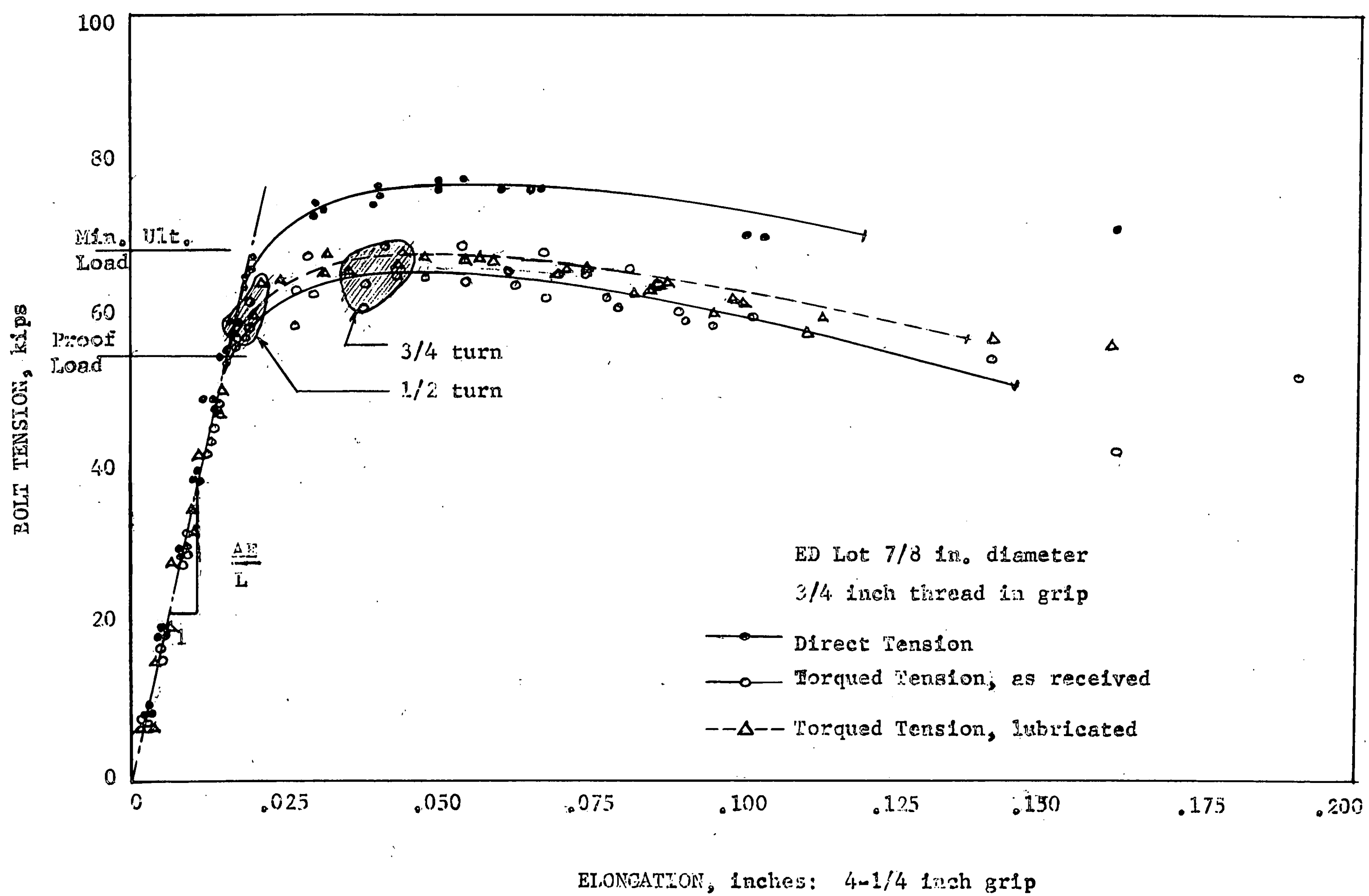

FIGURE 3: LOAD ELONGATION RELATIONSHIP, A354BD BOLT

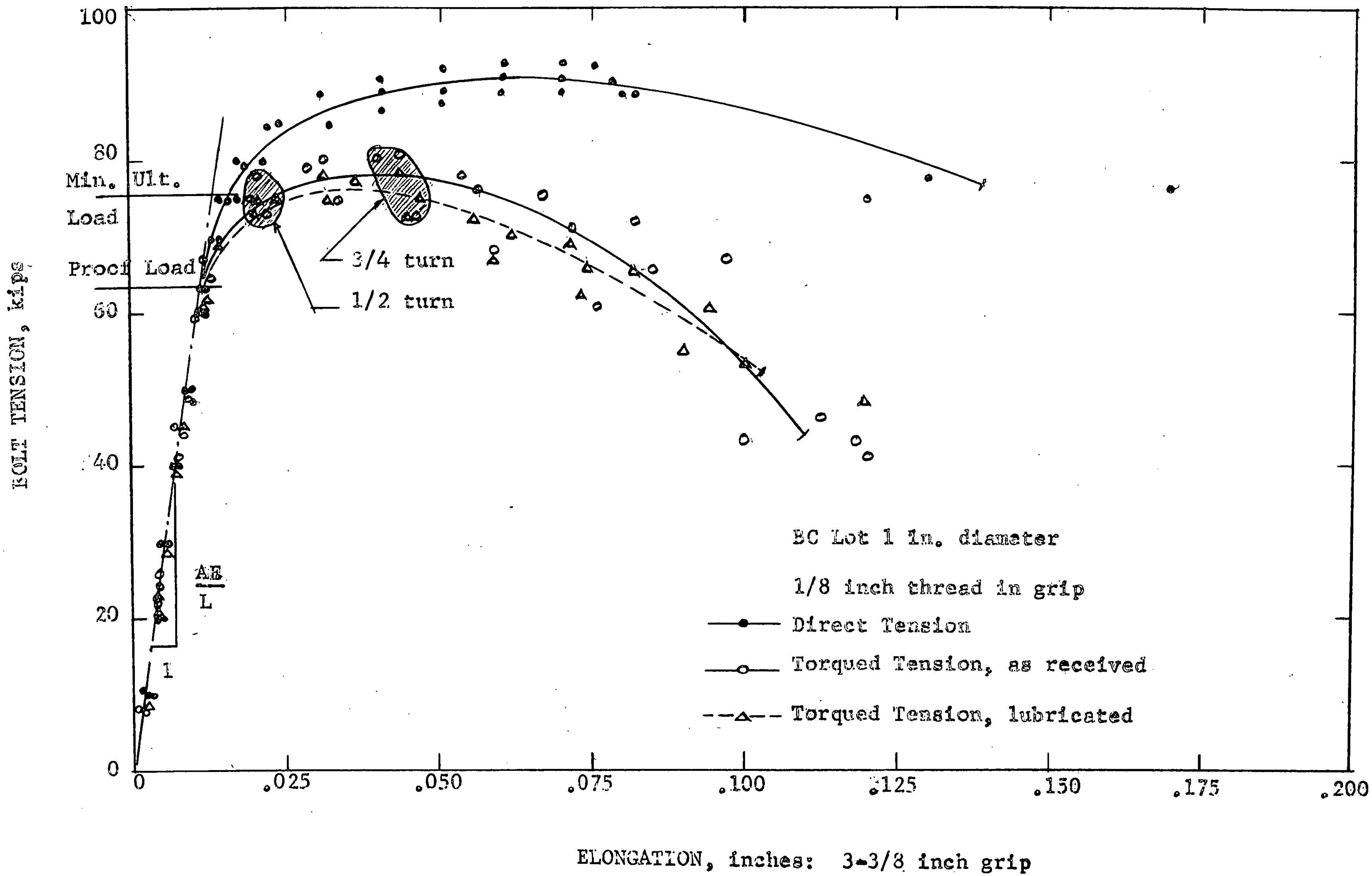

FIGURE 4: LOAD ELONGATION RELATIONSHIP, A354BC BOLT

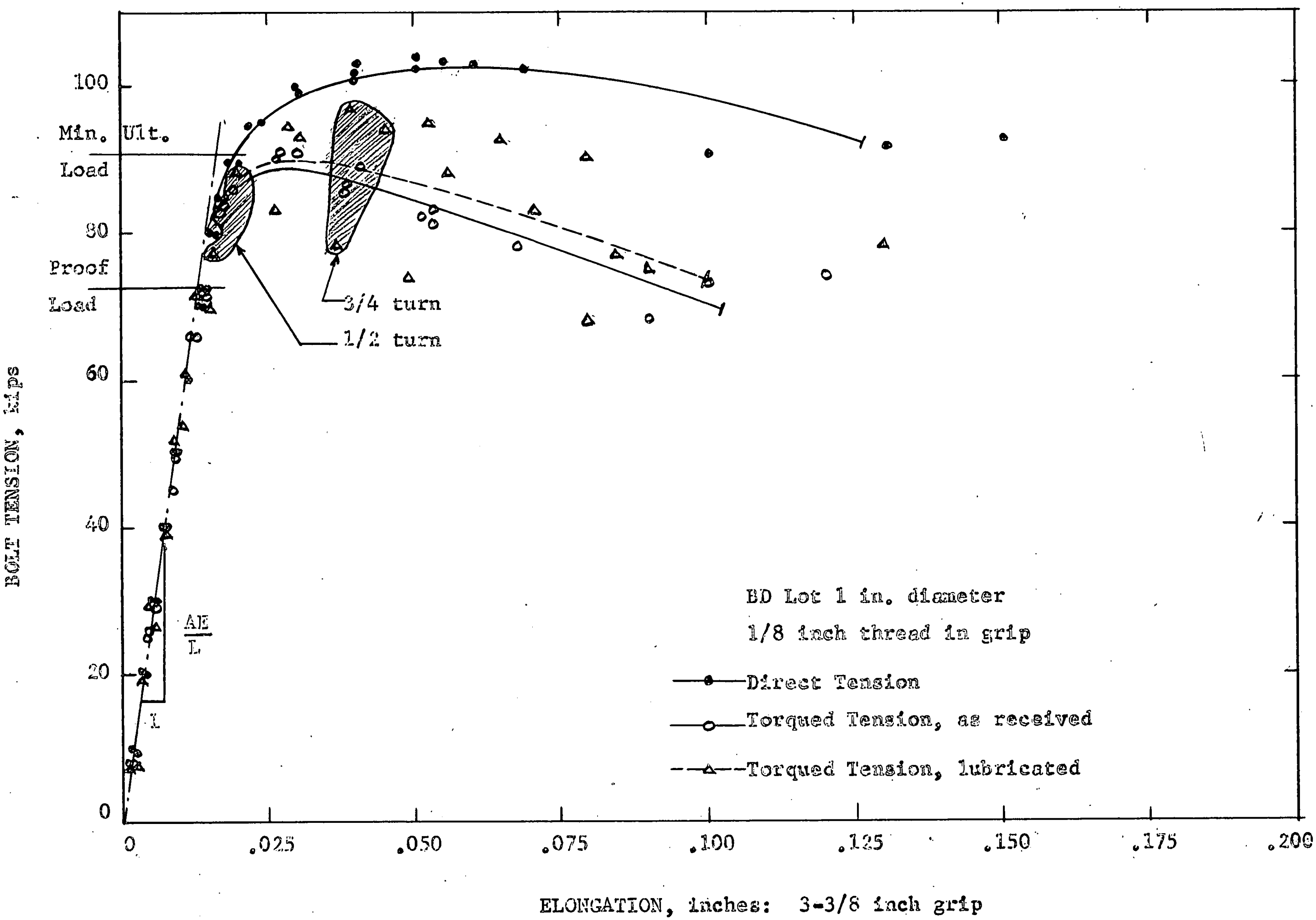

FIGURE 5: LOAD ELONGATION RELATIONSHIP, A354 BD BOLT

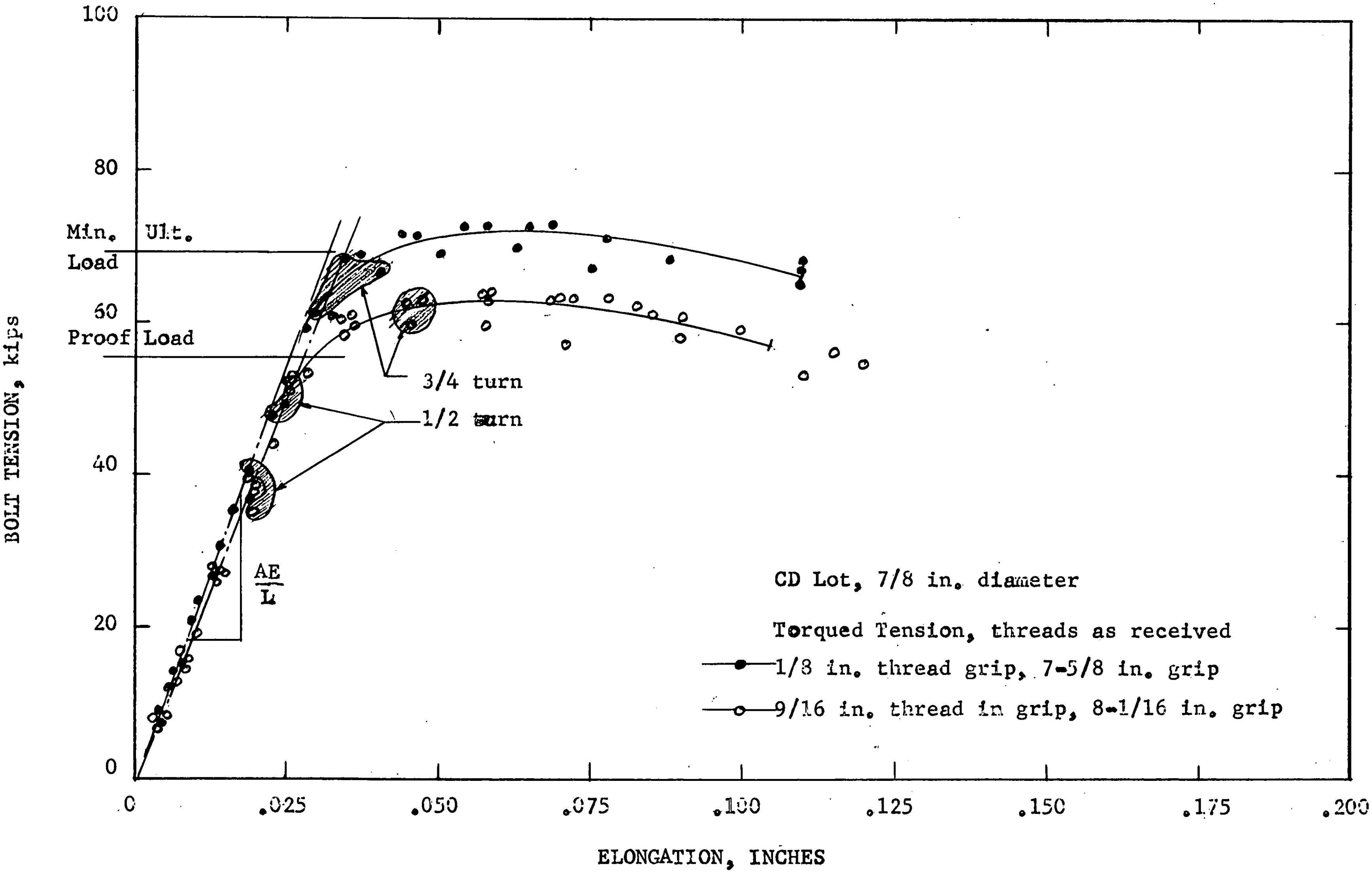

FIGURE 6: EFFECT OF THREAD LENGTH IN GRIP, A354BD BOLT

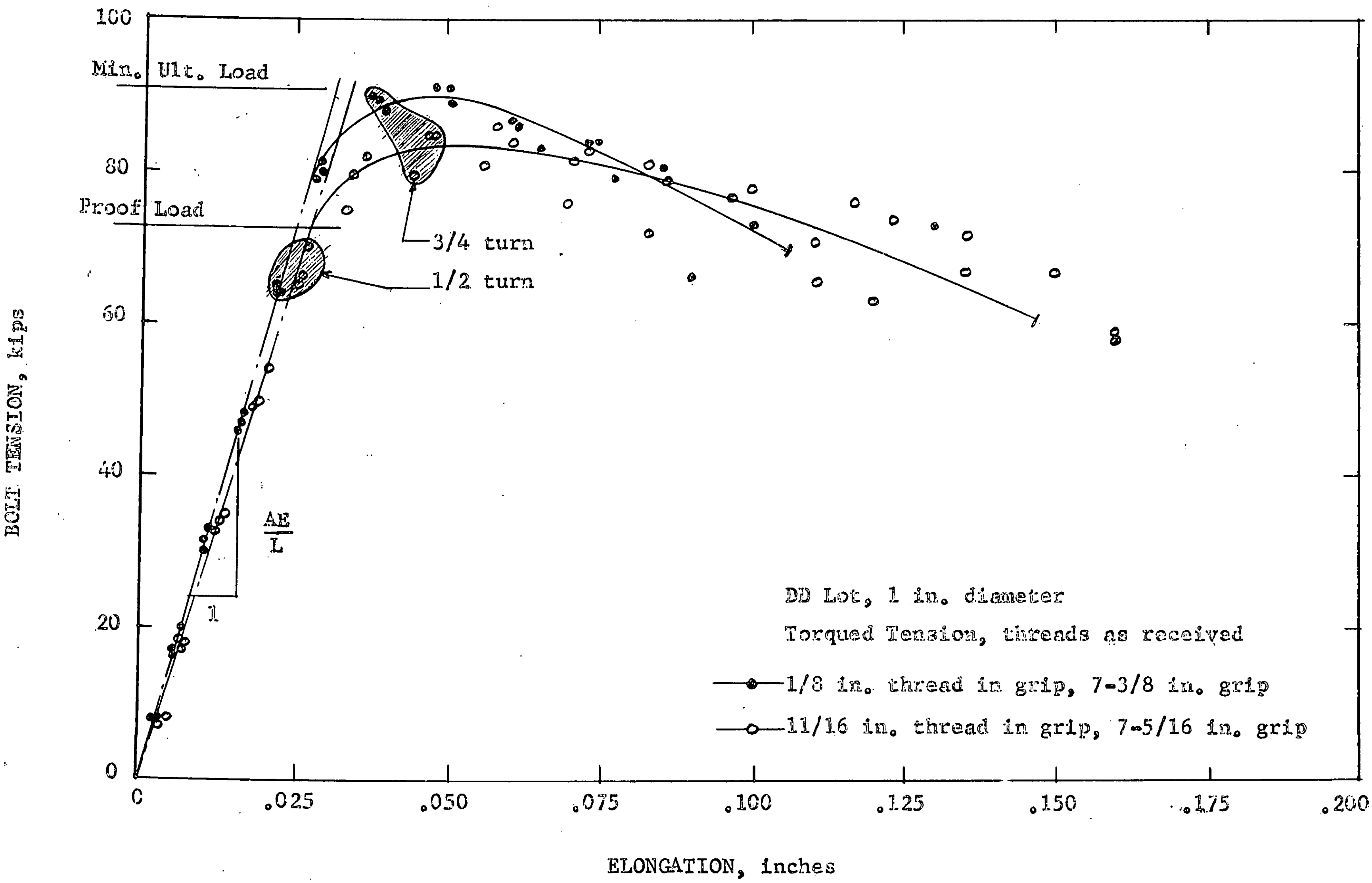

FIGURE 7:: EFFECT OF THREAD LENGTH IN GRIP, A354BD BOLT

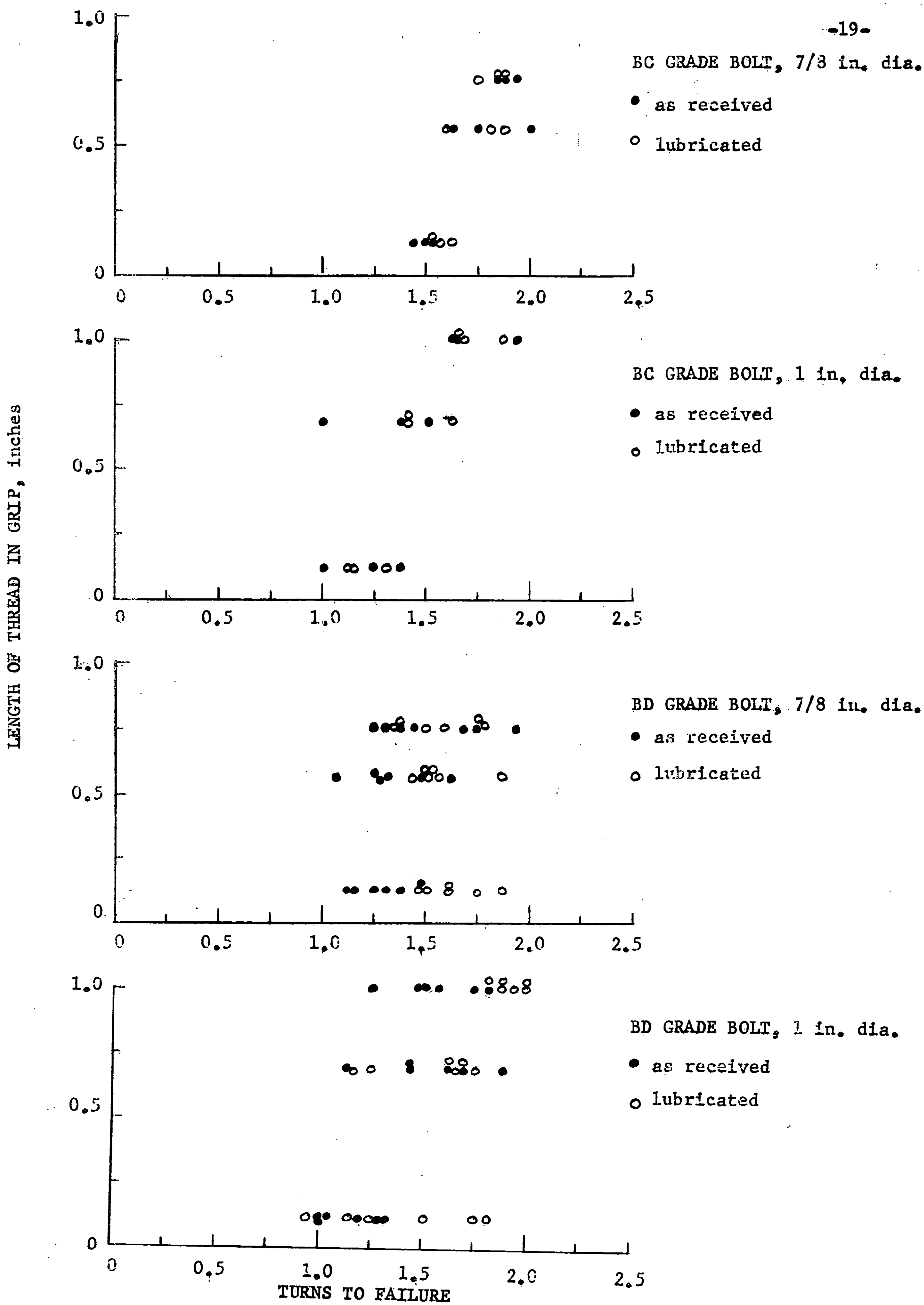

FIGURE 8: THREAD IN GRIP vs. TURNS TO FAILURE, A354BC AND BD BOLTS

APPENDIX A

TABLE 1

Program for Tensile Calibration of A354BC Bolts

Lot	AC		BC		CC	DC
Head Type	Hvy.		Hvy.		Reg.	Reg.
Diameter, in.	7/8"		1"		7/8"	1"
Length Under Head, in.	5.25		5.25		5.50	5.50
Thread Length, in.	1.75		2.00		2.00	2.25
Grip Length, in.	3.625	4.062	3.375	3.938	4.25	4.25
Thread in Grip, in.	0.125	0.562	0.125	0.688	0.75	1.00
Number of Tests:						
Direct Tension Tests*	3	3	3	3	3	3
Torqued Tension Tests* Threads as received	3	3	3	3	3	3
Torqued Tension Tests* Lubricated Threads	3	3	3	3	3	3
Repeated Torqued Tension to 1/2 Turn			6	6		
Combined Torqued and Direct Tension			6	6		
Continuously Torqued					3	

*Completed

APPENDIX A

TABLE 2

Program for Tensile Calibration of A354BD Bolts

Lot	AD		BD		CD		DD		ED	FD	GD	HD
Head Type	Hvy.		Hvy.		Hvy.		Hvy.		Reg.	Reg.	Reg.	Reg.
Diameter, in.	7/8"		1"		7/8"		1"		7/8"	1"	7/8"	1"
Length Under Head, in.	5.25		5.25		9.25		9.25		5.50	5.50	9.50	9.50
Thread Length, in.	1.75		2.00		1.75		2.00		2.00	2.25	2.50	2.75
Grip Length, in.	3.625	4.062	3.375	3.938	7.625	8.062	7.375	7.938	4.25	4.25	8.00	8.00
Thread in Grip, in.	0.125	0.562	0.125	0.688	0.125	0.562	0.125	0.688	0.75	1.00	0.75	1.00
Number of Tests:												
Direct Tension Tests*	3	3	3	3	3	3	3	3	3	3	3	3
Torqued Tension Tests* Threads as received	3	3	3	3	3	3	3	3	3	3	3	3
Torqued Tension Tests* Lubricated Threads	3	3	3	3	3	3	3	3	3	3	3	3
Repeated Torqued Tension to 1/2 Turn		3		3			3	3	3			
Combined Torqued and Direct Tension		3		3			3	3	3			
Continuously Torqued		3							3			

*Completed

APPENDIX A

TABLE 3

Program for Shear Calibration of A354 Bolts

Grade	BC				BD							
Lot	AC	BC	CC	DC	AD	BD	CD	DD	ED	FD	GD	HD
Head Type	Hvy.	Hvy.	Reg.	Reg.	Hvy.	Hvy.	Hvy.	Hvy.	Reg.	Reg.	Reg.	Reg.
Diameter, in.	7/8"	1"	7/8"	1"	7/8"	1"	7/8"	1"	7/8"	1"	7/8"	1"
Length Under Head, in.	5.25	5.25	5.50	5.50	5.25	5.25	9.25	9.25	5.50	5.50	9.50	9.50
Thread Length, in.	1.75	2.00	2.00	2.25	1.75	2.00	1.75	2.00	2.00	2.25	2.50	2.75
Grip Length, in.	4.125	4.125	4.25	4.25	4.125	4.125	8.125	8.125	4.25	4.25	8.25	8.25
Thread in Grip, in.	0.625	0.875	0.75	1.00	0.625	0.875	0.625	0.875	0.75	1.00	1.25	1.50

Number of Tests:

	AC	BC	CC	DC	AD	BD	CD	DD	ED	FD	GD	HD
Compression Shear New A440 Jig	3	To be completed after preliminary tests			3	3	3	3	3	3		
Compression Shear Used A440 Jig	3				3	To be completed after preliminary tests						
Tension Shear New A440 Jig	3				3							
Tension Shear Used A440 Jig	3				3							
Compression Shear New T-1 Jig	3				3	3	3	3	3	3		
Compression Shear Used T-1 Jig	3				3	To be completed after preliminary tests						
Tension Shear New T-1 Jig	3				3							
Tension Shear Used T-1 Jig	3				3							

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